

honest emulation. 2. The union affords greater facilities towards publishing transactions and securing the services of eminent lecturers. 3. An annual meeting of the associated societies affords an opportunity for the discussion of principles of working and promotes the general life. 4. The annual meeting being held in a fresh town each year helps to keep the country alive to the Association work, and encourages the formation of new societies.

The constitution of the Cumberland Association is as follows:—The president to be a man of local note and high culture, and to serve for a period not greater than two years.¹ The Presidents of individual societies to be vice-presidents of the Association. The council of the Association to consist of two delegates from each society, chosen annually. The treasurer and secretary (honorary) to be one and the same person, and fully acquainted with the county in all its aspects.

The working of the Association is carried on thus: The Association secretary keeps a record of all papers and lectures brought before the individual societies. Before the commencement of each winter session he communicates with all the local secretaries, and from his knowledge of available intellectual stores in the county, helps each in the drawing up of the winter programme in whatever direction help may be specially needed. It is his duty also to help forward the establishment of local classes where such are possible. At a council meeting held in the autumn some public lecturer is decided upon who shall go the round of the associated societies during the winter, and a grant is made towards his expenses from the Association funds (of which more anon), the rest being made up by each society served.

The annual meeting takes place at Easter or in May, and lasts two or three days. The Association President delivers his annual address, reports from the several societies are read and discussed, original papers are read, lectures given by one or more eminent men, and field excursions made.

At the close of each winter session the local secretaries send into the Association secretary any papers which have been selected by the local committees as worthy of publication. If the Association council approve these papers they are published in the *Transactions* at the Association expense. The funds of the Association are gathered thus: Each society pays an annual capitation grant of 6*d.* per head on all its members. There is also a class of Association members, residing at a distance from, and not belonging to, any local society, who pay an annual subscription of 5*s.*, and are virtually considered members of all the societies, and have the privileges of such. The *Transactions* are sold to the societies and Association members at the price of 1*s.*, the public being charged 2*s.* 6*d.* Some of the societies purchase copies to the full number of their members, and present them, others take only a limited number of copies (determined by the local society committee) and re-sell to those of their members who care to possess them. In this way the greater part of an edition of 800 copies of the *Annual Transactions* is disposed of. Authors are allowed extra copies of their own papers at a moderate charge, and when all expenses are met, a fair balance is left to carry on to the next year.

It should be noted that of the eight societies in Cum-

¹ The Lord Bishop of Carlisle acted as president for two years, and I. Fletcher, M.P., F.R.S., is now in his second year of presidency.

berland, now associated, the local annual subscriptions of members in each society is generally 5*s.*; in one case, however, it is 3*s.* 6*d.*, and in another 2*s.* 6*d.* It is a rule of the Association that members going from one society to another to afford help in the carrying out of the various programmes, should have their expenses paid by the society helped. Such is the general constitution and mode of working of the Cumberland Association, which has undoubtedly succeeded in its aim, so far as the keeping up of existing societies and the formation of new ones is concerned. The *Annual Transactions*, too, include many papers of local value, and some of general interest, while among the eminent men who have kindly come forward to lend their services at the Annual Meetings, are the Astronomer-Royal, the Bishop of Carlisle, Prof. Shairp, Prof. Wm. Knight, and I. Fletcher, M.P., F.R.S. At present, however, the Association is but in its infancy, and may be considered more or less of an experiment, yet that some such method of union is desirable amongst local societies in the various counties or districts of England few will deny. Time will show how the system may be improved and varied to suit special circumstances, but I cannot but think that the plan of association to carry out the larger objects of societies, and the annual meeting of the associated societies in successive towns of a county, must economise labour and promote the healthy culture of the county in which the work is carried on.

Amongst the difficulties presenting themselves in the early days of the association, the following occurred. For several previous years a Cumberland and Westmoreland Antiquarian and Archæological Society had flourished, and it was feared that the new County Association would clash with its existence. The Antiquarians thought it best not to amalgamate with the associated society, its constitution being in many points different from theirs, but it was resolved that whenever papers, bearing on local antiquarian or archæological subjects were read before any of the associated societies, these papers should be offered by the Association council to the Antiquarian and Archæological Society for publication in their *Transactions* if deemed worthy. Moreover, some of the officers of the Association are active members of the Archæological Society, and so far from their being any antagonism, the two decidedly help one another forward in the general work of gleanings local knowledge and diffusing culture.

As hon. secretary of the Cumberland Association, I should feel very grateful for any hints or suggestions from the readers of NATURE. What is wanted in every county is more culture, and that carried on in a *natural* way, and with a true love of nature in all her aspects.

J. CLIFTON WARD

NEWCOMB'S LUNAR RESEARCHES

Researches on the Motion of the Moon, made at the United States Naval Observatory, Washington. By Simon Newcomb, Professor U.S. Navy. Part I. (Washington, 1878.)

THE author prefaces his work with the remark that for several years after the publication of Hansen's Tables of the Moon, there was a very general belief that

the motion of our satellite could be followed by their means with the same accuracy as that of the other heavenly bodies, after having been made the subject of astronomical and mathematical research for two thousand years. This expectation was soon proved to be far from borne out. Prof. Newcomb showed in 1870 that the accuracy of the Tables since 1750 had been secured only by sacrificing the agreement with observations previous to that epoch, and that about 1700 the Tables deviated more widely from the observations than the previous ones; and it may be added that those who had been engaged in examining the old eclipses were aware that Hansen's Tables did not represent the phenomena only as far back as the commencement of the eighteenth century, so well as Burckhardt's or Damoiseau's, which had been used for our ephemerides up to the date of their publication.

A new investigation of the subject for the purpose, if possible, of ascertaining the cause of these unexpected deviations was entered upon at the Naval Observatory, Washington, and was made a part of our author's official duties in that establishment. In the present volume we have the results of researches on the discordances in question, based upon observations before the year 1750. This portion of the work was originally intended to follow the study of the mathematical theory of the inequalities of long period in the moon's mean motion, but for reasons explained in the Introduction, that part of the inquiry is still incomplete. The year 1750 was fixed upon as the terminal point in the investigation in this first part, as it is the epoch when exact meridian observations commenced, and that which separates the period within which we are in possession of observations reduced on modern data, from the period during which neither really accessible observations nor tables of reduction are available.

Prof. Newcomb supplies an historical introduction in which the discovery of the secular acceleration, and the examinations of ancient eclipses with the view to fix its correct amount by observation are briefly noticed, as also Ferrel's paper, published in 1853, containing "the first known attempt to calculate from theory the retardation produced by the action of the moon upon the tidal wave," and the researches of Adams and Delaunay. He proceeds to give a summary of the data now at our disposal for determining the apparent secular acceleration of the moon from observation alone. These include the statements of ancient authors from which it has been inferred that total solar eclipses have been witnessed at certain points of the earth's surface at dates approximately indicated, and the author points out the uncertainty attending our interpretation of such records. He considers that the circumstance which we should regard as most unequivocally marking the totality of an eclipse is the visibility of stars, though he thinks that even this criterion is hardly to be admitted as conclusive, because Venus may be seen during a considerable partial or an annular eclipse, and at certain times when there is no eclipse at all, there is also another difficulty in some cases, in determining the precise localities where the phenomena were observed. We have also the series of lunar eclipses upon which Ptolemy founded his theory and which are recorded by him in the *Almagest*. These are followed by the observations of the Arabian astronomers, chiefly contained in

an Arabic manuscript belonging to the University of Leyden, a translation of which was made by Caussin and published by the French Government in 1804, under the title "*Le Livre de la Grande Table Hakémité*." Prof. Newcomb remarks that this work contains what are entitled to be considered the earliest astronomical observations of eclipses which have reached us, for although some of the data furnished by Ptolemy, Theon, Albategnius, and others, may have been the results of astronomical observations, in no case have the quantities actually observed been handed down to us. The entire number of eclipses in this collection is twenty-eight, and the times of concluded beginning and ending were usually determined by noting the altitudes, which were recorded sometimes in whole degrees only, at others "in coarse fractions of a degree." There must remain a doubt how nearly such times apply to those of actual contact, but Prof. Newcomb suggests in this part of his work that by the mean of all the observed times the error in the moon's mean longitude can be reduced to not more than a minute of arc. The Arabian observations are followed by those of European observers prior to the invention of the telescope, including Regiomontanus, Bernard Walther, and Tycho Brahe: of the latter, the author remarks, "It is wonderful if so indefatigable an observer never observed an occultation of a star or planet by the moon, yet I have never succeeded in finding any such;" he made a careful examination of Tycho's observations during periods in which the bright star Aldebaran must have been occulted, to no purpose. The observation of eclipses and occultations with the aid of a telescope, Prof. Newcomb remarks, may be considered as commencing with Bullialdus and Gassendus, but they had no clock, and only fixed the time by noting the altitude of the sun or a star. The application of the clock commences with Hevelius, and in the scarce volume of his "*Machina Cœlestis*" are found a number of occultations thus observed. Then follow the observations of Flamsteed and the astronomers at the observatory of Paris, the Cassinis, La Hire, and Delisle, the latter of whom also observed at St. Petersburg. Prof. Newcomb, during a visit to Paris, while Delaunay was in charge of the Observatory, was fortunate in having all the archives of that establishment unreservedly placed at his disposal. He found amongst them most of the original note-books of the French observers since the year 1675, in which were contained a great number of occultations that had been quite forgotten, those which had appeared in the *Memoirs* of the Academy, forming but a small fraction of the whole. Again, on visiting Pulkowa, M. Struve gave him access to the records of Delisle's observations, 1727 to 1747, forming a useful supplement to those of Paris, which had diminished in number after 1720.

Prof. Newcomb concludes this historical notice with remarks on observations since the time of Bradley, and granting certain fundamental premises, suggests that the secular acceleration of the moon may admit of nearly as accurate determination from the modern observations, as from their combination with the ancient ones.

Having thus briefly recapitulated the data available for investigation, the author adverts to ancient eclipses, presumed to have been total from the narrative of the historians, at certain points of the earth's surface. The

eclipses he admits in this category are eight in number, from that of Thales, B.C. 585, to the eclipse of A.D. 364, described as total at Eoos. Looking for mention of distinct indications of totality, he has not included such an eclipse as that of B.C. 763, the record of which was discovered by Sir Henry Rawlinson on one of the Nineveh Tablets in the British Museum, where importance appears to be attached to it by the description being underlined; hence its presumed totality. The eclipses of the moon recorded by Ptolemy in the *Almagest* are thoroughly examined, with satisfactory results, except in the case of the eclipse of B.C. 383, December 22, where there appears to be a mistake as to its having been really observed at Babylon; and he concludes that during the eight centuries preceding the Christian era the mean longitude of the moon in Hansen's Tables requires a correction of about 18'. The Arabian eclipses, solar and lunar, twenty-five in number, between A.D. 829 and 1004 are then compared with the Tables.

In the next two sections Prof. Newcomb supplies a full description of the method adopted for deducing the errors of the lunar elements from the eclipses and occultations, and for determining the effect of changes in the elements upon the path of the central line of an eclipse, adopting, in the latter case, formulæ originally given by Bessel.

In a following portion of the volume, occupying about a hundred pages, are given, mostly as originally recorded, the observations of occultations and eclipses by Bullialdus and Gassendus, Hevelius, and, as the author terms them, the astronomers of the French School, between 1670 and 1750, preserved in the archives at the observatories of Paris and Pulkowa; it is needless to say that this section possesses a great value, supplying as it does the particulars of so many observations hitherto unpublished. We have then the positions of the moon from Hansen's Tables, used in the comparison of the preceding observations with theory, in the calculation of which, and for the numerical work generally, Prof. Newcomb was assisted by a grant from Congress, sufficient to enable him to employ two computers. Certain modifications of the strict form of application of the Tables were considered allowable for the older observations, their degree of accuracy rendering an exact computation of Hansen's Fundamental Argument of no advantage, and he considers such modified plan of employing Hansen's Tables, preferable to the use of the older Tables, which might be adopted for the sake of saving labour. A "Tabular exhibit of Reduction of the Occultations," 286 counting immersions and emersions separately, is then given. The equations of condition for the occultations, and a provisional solution follow.

In the next section the author presents an elaborate discussion of eclipses from 1620 to 1715, which it may be remembered is the last total eclipse that was methodically observed in this country. In this series is included the eclipse of 1639, June 1, observed by Gascoigne and Horrox amongst others, and 1706, May 11, which was total in the south of France, but of which Prof. Newcomb takes no other observations into account than those of La Hire, of Paris: the fact, indeed, is that the observations along the belt of totality appear to be strangely and unaccountably discordant, so far at least as regards the beginning and ending of the total phase. The eclipse of

1715 is very fully discussed, and remarking that by Halley's organisation of a numerous body of observers throughout the path of the moon's shadow across England, valuable observations for determining its limits were procured, the author deduces from them a correction to the motion of the moon's node, which he finds to be $10'' \times T$ (T being counted in centuries from 1850), the argument of latitude being diminished by this amount; this result he considers nearly certain with respect to its algebraical sign, but observes that it must be affected by any corrections of Hansen's value of the moon's parallax.

We now reach the main conclusions to which Prof. Newcomb is led, by the laborious and masterly discussion of observations prior to 1750, of which necessarily little beyond an outline has been given here. The theoretical value of the secular acceleration of the moon's mean motion due to the cause discovered by Laplace, has been fixed with accuracy by Prof. Adams and Delaunay: the latter geometer, carrying his approximation to a greater number of terms than had been included by Prof. Adams, assigned $6''.18.T^2$. But this value, as is well known, has not been found to accord with the older observations, and the difference between the theoretical value and that which observation seemed to require, has been generally attributed to a retardation of the earth's axial rotation; thus, as Prof. Newcomb remarks, "the apparent secular acceleration will be made up of two parts—the one a real acceleration, the other an apparent one, due to the change in our measure of time. But further, he says it will be found that the hypothesis of a constant tidal retardation does not account for the observed mean motion of the moon, and either the retardation must be supposed variable, even to becoming at times an acceleration, or it must be admitted that her mean motion is affected by changes not hitherto explained. He then proceeds to inquire what deviations of the moon's mean motion remain unaccounted for, and with this object he first collects into tabular form the individual corrections to Hansen's mean longitudes, derived from the discussion of eclipses and occultations from 1621 to 1728, with their probable errors, the latter being necessarily somewhat arbitrary, for want of data for their rigorous computation. The older results do not exhibit larger discordances than might be expected. In order to complete the investigation of anomalies in the moon's mean motion unexplained, it was necessary to have the errors of Hansen's Tables from 1750 to the present epoch, or to 1875, and these were partly obtained from Hansen's paper in the *Monthly Notices* of the Royal Astronomical Society, and, since 1850, from Part III. of the publications of the American Transit of Venus Commission, where it was shown by Prof. Newcomb that at the epoch 1875.0 the meridian observations at Greenwich and Washington agreed in indicating a correction to the tabular mean longitude of $-9''.7$. The occultations about the same time giving a correction nearly two seconds less, it is assumed that the true correction at this epoch was $-8''$. Hansen introduced in his tables a term depending on the argument, 8 times the mean motion of Venus minus 13 times the mean motion of the earth, which has not been theoretically explained, and is to be regarded as empirical. This term is therefore removed from the theory, before examining, as Prof. Newcomb proceeds to

do, how nearly theory alone, without any empirical correction, will represent the observations. It is then at once apparent that the residuals cannot be represented by corrections to the epoch of mean longitude, mean motion, and secular acceleration, and any approximation to a mean value of the latter would have different values, according to the mode of using the data. To obtain the best result from the ancient and modern observations combined, it was deemed advisable to assign a minimum probable error of 4" or 5" to each residual for the modern observations. Equations of condition for correction of epoch, mean motion and acceleration are formed, and extend from B.C. 688 to A.D. 1875, or over a period of 2,500 years, and the resulting corrections to Hansen's values for 1800, are, for mean longitude, $+3''.90$, mean motion $-19''.03$, and for secular acceleration $-3''.36$; Hansen's adopted value of the latter being $12''.17$, the value which best satisfies the observations discussed by Prof. Newcomb is found to be $8''.8$. Though he considers this correction to the tabular acceleration to be clearly indicated, the residuals for the modern observations are yet of such magnitude as to be wholly inadmissible, and therefore the theory in its present state will not represent observations with any value of the secular acceleration, and respecting the cause of the magnitude of these remaining differences, he makes two hypotheses: (1) that they are only apparent deviations caused by inequalities in the earth's axial rotation, (2) that they arise from one or more inequalities of long period in the actual mean motion of the moon. Examining the effect of the first hypothesis, he arrives at the conclusion that if it be correct "the problem of predicting the moon's motion with accuracy through long intervals of time must be regarded as hopeless since it cannot be expected that variations in the earth's axial rotation will conform to any determinable law," and, he adds, "success in tracing the deviations in question to the moon itself and to the theory of gravitation is therefore a consummation to be hoped for." With regard to the second hypothesis, it is seen that the residuals of the equations of condition indicate that the modern observations may be nearly represented by a term having a period of between 250 and 300 years, and hence Prof. Newcomb inquires how closely an empirical correction to Hansen's first term depending upon the action of Venus, the period of which is 273 years, will accord with the modern observations, and he finds a very satisfactory agreement. An additional diminution of $10''$ in the secular mean motion of the moon results, which at the present epoch involves a further diminution in the secular acceleration of $0''.5$, that the ancient observations may be well represented; thus the acceleration becomes $8''.3$. T^2 . A table is given exhibiting the corrections to Hansen's mean longitude from 1620 to 1900 for every tenth year; in 1880 it is $-11''.2$, and in 1900 $-24''.6$.

This important volume concludes with some remarks upon the bearing of the value of the moon's secular acceleration deduced from the investigations, of which we have endeavoured to give a general outline here. Prof. Newcomb thinks it is apparent that one of two propositions must be accepted: "Either the recently accepted value of the acceleration and the usual interpretation of the ancient solar eclipses are to be radically altered, the eclipse of

-556 not having been total at Larissa, and that of -584 not having been total in Asia Minor; or the mean motion of the moon is, in the course of centuries, subjected to changes so wide that it is not possible to assign a definite value to the secular acceleration." It is certain that there will be a difference of opinion upon his main conclusions, and for this he expresses himself fully prepared. If a definite theory of the apparent inequalities of long period in the moon's motion cannot be formed, or if the moon's mean motion is subject to such changes from age to age that no invariable and well-defined value of the secular acceleration can be deduced, then he urges it is not certain that the question whether Hansen's tabular mean longitude during centuries preceding the Christian era does or does not require a considerable negative correction can ever be conclusively settled, since no conclusions can be drawn except from observations made near the period in question, and he advocates the necessity of a further investigation into the eclipses and other data on the two hypotheses, first that Hansen is correct during the period named above, and second, that a correction of $-16'$ is required, and suggests that the question should be examined in this manner by some independent authority. If, on the other hand, it is not possible to form a perfect theory of all the inequalities in the moon's mean motion independently of observations, he thinks it will be practicable to arrive at a value of the secular acceleration from the modern observations, reliable within $0''.5$.

ROScoe AND SCHORLEMMER'S CHEMISTRY

A Treatise on Chemistry. By H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S., Professors of Chemistry in Owens College, Manchester. Vols. i. and ii. (Macmillan and Co.)

THIS work is a most valuable contribution to the literature of chemistry. Its aim, as stated in the Preface, is to place before the reader a fairly complete, and yet a clear and succinct statement of the facts of modern chemistry, whilst at the same time entering so far into a discussion of chemical theory as the size of the work and the present transition state of the science permit, special attention being also paid to the accurate description of the more important processes in technical chemistry, and to the careful representation of the most approved forms of apparatus employed.

The manner in which this design has been carried out is such as might have been expected from the high reputation of the authors. The work commences with a very interesting historical introduction, in which the progress of chemistry is traced from the early times, in which it was merely an art subservient to alchemy, medicine, and a few branches of manufacture, to the time when, by the gradual accumulation of observations, and the discussion of them by men of philosophic mind, it rose to the rank of a science. A clear and impartial discussion is given of the relative merits of the various workers by whose labours the system of chemical philosophy now accepted was developed, showing how the phlogistic theory of Becher and Stahl first established a common point of view from which all chemical changes could be regarded,